PALEONTOLOGICAL NOTES, NO. VI.

# ON SUPPOSED MEROSTOMATOUS AND OTHER PALEOZOIC ARTHROPOD TRAILS, WITH NOTES ON THOSE OF LIMULUS.

By Alpheus S. Packard.

Presented May 9, 1900. Received May 22, 1900.

Trails or tracks evidently made by paleozoic arthropods have occurred most abundantly in the Potsdam sandstone (Cambrian) of Canada and New York, also in the Hudson River or Cincinnati stage of the Ordovician Period. We have now to add descriptions of tracks of a similar nature from the Chemung stage (Upper Devonian) and from the Upper Carboniferous. We will give the name *trail* to the entire series of footprints, and restrict the word *track* to the individual footprints. The trails discovered by Logan, and carefully described by Professor R. Owen,* were very large, being six inches wide and several feet long, and were evidently made by some large trilobite (as first suggested by Dana) with a caudal spine, as there is a well-marked median furrow. Whether the trilobite was a Paradoxides or not is uncertain, because the species of this genus are without a definite caudal spine, such as is to be seen in Dalmanites and certain other trilobites of a later period than the Cambrian. But aside from this the tracks, in sets of seven and eight, seem most probably to have been made by an arthropod with numerous pairs of jointed cylindrical legs, such as we now know, through the researches of Walcott and of Beecher, trilobites possessed. Professor Owen described six species of the tracks, for which he proposed the generic name of Protichnites, but we venture to suggest that it is not improbable that they were all made by a single species of trilobite, as observation has taught us that Limulus may make tracks of very dissimilar shape. We would suggest that to trails consisting of sets of several, or as many as

* Journal Geolog. Soc. London, VIII. pp. 199, 214. 1852.

These trails, *Protichnites septem-notatus* Owen, are figured on a reduced scale in Dana's Manual of Geology, Fig. 256; and *P. octonotatus* Owen in the new edition of Bronn's Lethæa geognostica.

7 or 8, individual tracks, the term Protichnites be restricted. Logan's *Climactichnites wilsoni*, six and a half inches wide and thirteen feet long, also from the Potsdam sandstone, which Dana suggested may have been made by a large trilobite,* seems to be such. There is an interrupted median furrow; the oblique furrows were probably made by the legs, and the lateral furrow bounding the track is much like that made by the cheeks or sides of the head of Limulus.

We now come to similar but less complex tracks described by O. C. Marsh, † also from the Potsdam sandstone near Port Kent, N. Y. This trail was about six feet long, and the tracks were separated from each other "by a space of about one and three-fourths inches, and having an extreme width between their outer edges of two and a half inches." In this trail there is no median furrow, no lateral ridge, and here and there are double tracks, as if they were footprints made by a second anterior pair of feet. The track has a decided merostomatous appearance, but was probably made by a trilobite, as there are no Limuloid merostomes known to have existed in the Cambrian, and the track could scarcely have been made by an Eurypterid.

The next set of paleozoic trails are those described by Miller and Dyer ‡ in 1878, in a fine hard shale of the Cincinnati's stage of the Ordovician Period at Cincinnati. The originals are in the Museum of Comparative Zoölogy at Cambridge, Mass., and I am indebted to Dr. R. T. Jackson for the privilege of examining them. One of them is similar to that described below from Providence, but the trail is twice as wide, and the tracks not so wide. They were perhaps made by a trilobite; there is no median furrow, or lateral ridges. §

*The trails of Limulus polyphemus.* — Figs. 1, 2 (one-third natural size). The trail made by this merostome has been described and figured by the late Sir J. W. Dawson in the Canadian Naturalist, VII. p. 271. He gives three interesting figures of the trails left by a single small Limulus four inches wide on a sandy shore. In each of his figures the median furrow is distinct, but the lateral marks are furrows "with slight ridges exterior to these," while my example left only a ridge. The

* Manual of Geology, p. 189 (first? edition), Fig. 259.

† Amer. Journ. Sc. and Arts, XLVIII. July, 1869. Plate.

‡ Journ. Cincinnati Natural History Society, 1878.

§ The trails figured by Emmons (Agriculture of New York, I.) as *Nereites jacksoni pugnus* and *loomisii*, appear to be Annelid trails, and none of those figured by James Hall (Paleontology of New York, II. Pls. 13–16) seem to have been made either by trilobites or merostomes.

footprints were slightly oblique series of four punctures, or pits, "deepest behind, in which the four marks left by the nails of the posterior feet were most prominent, and sometimes the only marks seen."

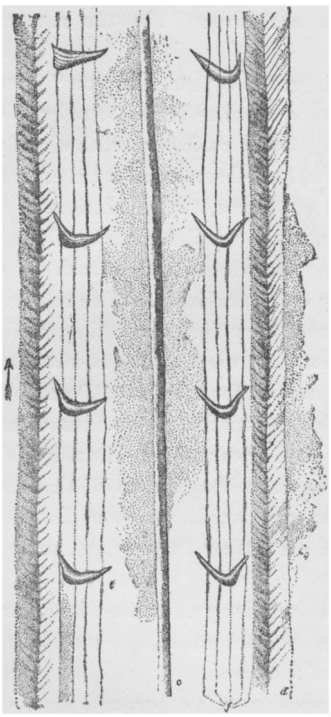

FIGURE 1.

FIGURE 2.

"When the Limulus creeps on quicksand, or on sand just covered with water, so that its body is partly water-borne, it appears principally to use its ordinary walking feet, and the footprints then resolve themselves into a series of longitudinal scratches after the manner of *Protichnites lineatus*." . . .

"When placed in shallow water, just covering the body, the creature used its flat abdominal swimming feet, and though the impression made was very faint, and not readily observed under water, it was obviously very different from those before mentioned, agreeing with them only in the lateral and median grooves, while between these were series of furrows extending obliquely from each side of the middle groove, and re-

sembling ripple marks (Fig. 3). These were produced by the sand swept up by the swimming feet." Dr. Dawson then compares the trail represented by his Fig. 3 with Logan's Climactichnites, and they are remarkably similar, except that the oblique furrows made by the legs between the median and lateral ridges are directed in the reverse direction.

Of the tracks afterwards described and figured by Dr. Dawson * from the upper Carboniferous of Nova Scotia, none seem to me to be referrible to trilobitic or merostomatous trails. *Protichnites carbonarius*, as already remarked in these Proceedings, † appear to have been made by a crustacean, and we have referred them to a distinct genus, *Ostrakichnites*.

Some years ago I made some experiments with small Limuli by placing one in a shallow tin pan, in which the sand was about half an inch deep, and the water not deep enough to entirely cover the body. The animal, so far as I can now remember, used its ambulatory feet in walking, while the swimming or abdominal legs were partially used. The result may be seen in Fig. 1. The king-crab was about four inches (10 cm.) in width. The trail it made consisted, besides the tracks themselves, of an outer ridge made by the outer edge of the head or carapace; this ridge (*d*) was about 15 mm. in width, and was due to the heaping up of the fine sand; in section it would be low conical; one would suppose that the action of the edge of the head would make a furrow rather than an elevated ridge.

The tracks (*t*) were opposite, and quite regularly concavo-triangular, the apex of the triangle rounded, and directed backwards, the sand being pushed slightly up on the posterior edge of the track.

The tracks of each side were directly opposite each other, and those of each pair directly in line with those of the pair in front. It was noticed that the distance apart of the tracks varied with the rapidity of the half-walking, half-swimming movements of the animal. It was seen that the tracks were made by the hindermost, or sixth pair, of limbs only, no impression being left in the sand by the feet in front. The triangular shape of the track was due to the spreading out of the two spatulate spines of the last segment of the leg. It should be observed that the distance apart, outside measurement, of the tracks is about two-thirds that of the entire trail.

---

* Impressions and footprints of aquatic animals and imitative markings on carboniferous rocks. Amer. Journ. Sc. and Arts, 3d Series, V. Jan. 1873, pp. 16–24, Figs. 1–5. Also Acadian Geology, 2d edit. Supplement. 1878.

† XXXV. April, 1900, p. 403.

The four narrow furrows (*f*) intersecting the tracks were made by the lateral abdominal spines, which are bent down and trail in the mud or sand when the animal is walking or moving over the bottom. The large, deep, median furrow (*c*) was made by the caudal spine; it was continuous, uninterrupted, during the continuous forward movements of the animal.

Another trail is represented by Fig. 2. It will be seen that it presents no resemblance to the other. Unfortunately I did not make any notes as to the relations of the animal to the bottom. So far as I can remember it was a smaller individual, and probably it moved rapidly. The indentations on the margin of the trail were evidently made by the feet, while the series of median furrows were made by strokes of the caudal spine. The trail was 3.50 cm. wide.

*The tracks of living terrestrial Isopod Crustaceans.* — Fig. 3. In this connection it was interesting to ascertain the nature of the tracks made by Crustacea so much like trilobites in general shape as our terrestrial Isopods. One of our common Armadillo was captured, its feet inked, and it was then set free and allowed to "make tracks" on a sheet of paper. It will be remembered that the Isopods have seven pairs of ambulatory legs, the extremities of which end in a single sharp point. The width of the body is from 4 to 5 mm. It was noticed that the crustacean in running put down the feet of each pair at the same time, and that the legs, and especially the pointed extremities, were perpendicular to the surface over which it ran.

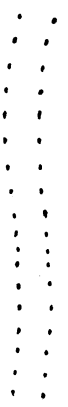

FIGURE 3.

The trail thus made was a very simple one, being a double row of slightly elongated dots, the individual tracks of each pair being exactly opposite to each other, as seen in the figure. When the feet dragged the dots became lines. The trail is also nearly of the same width as the body itself, though a little narrower rather than wider.

A specimen of our common *Porcellio scaber* was also compelled to undergo similar treatment and like evolutions with the same result. The trail differed in no essential respects from that of the other Isopod.

It will be of much interest to experiment with macrurous and brachyurous Crustacea, in order that the results may throw light on the numerous tracks in the Triassic beds of the Connecticut Valley described by Hitchcock in his "Ichnology."

*Merostomichnites beecheri* n. sp. Fig 4. This trail is in a fine shaly sandstone of the Chemung beds at Warren, Pa. It covers an area

3 cm. long and about 9 mm. wide. It is straight and short. The individual tracks are opposite each other, as in those of Limulus. The animal must have leaned more to the right side, as the tracks on this side are larger, deeper, and much more perfect than on the left side. The most perfect ones are in shape almost exactly like those made by Limulus when half walking and half swimming in very shoal water. A typical track may be described as forming a low triangle, the apex pointing backward; it is hollow, the interior forming a hollow triangle surrounded by a raised ridge.

There are six pairs of tracks, with traces of a seventh. The width of the trail is 9 mm., but probably if the entire trail were perfect on the left side it would have measured about 10 mm. in width. The tracks are opposite to each other. The largest and best marked individual track is 5–6 mm. wide and 3 mm. deep (or long) from in front to the apex or hinder part. The tracks of each pair are very near to each other, and those in the front part of the trail tend to be united into a simple transverse ridge.

There are no secondary tracks in between the others, and in this respect the track differs from that of *M. narragansettensis*, and resembles that of Limulus.

The original of this track is in the paleontological collection of the Peabody Museum of Yale University. I am indebted to the kindness of Professor C. E. Beecher, the curator, who did me the favor to send me an excellent cast, from which the above description has been made. Professor Beecher informs me that in the beds of the Chemung group at Warren, Pa., there are no remains of trilobites; and he expressed his belief that the tracks were those of some merostome. It is to be observed that there is no median furrow or trail made by a tail or caudal spine, and no furrow or ridge made by the edge of the body or carapace. The merostome which made it most probably had no caudal spine. And yet the tracks are otherwise very similar to those of Limulus. It may be observed that all the Eurypterida are provided with a telson, either broad or narrow and spine-like, and their trails would evidently include a furrow made by such a spine. The Limulidae were represented in the Devonian by *Protolimulus eriensis* Williams ("associated with typical Chemung fossils"). Was this track made by a young individual of this genus, with the caudal spine too short to make a trail? If not, was it made by a Bunodes, which lived in the Upper Silurian of Europe, but has not yet been discovered in America, and had no caudal spine? But Bunodes would perhaps have left a lateral furrow made by the broad thin edge of

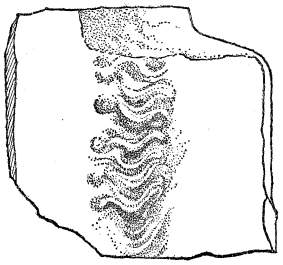

FIGURE 4.

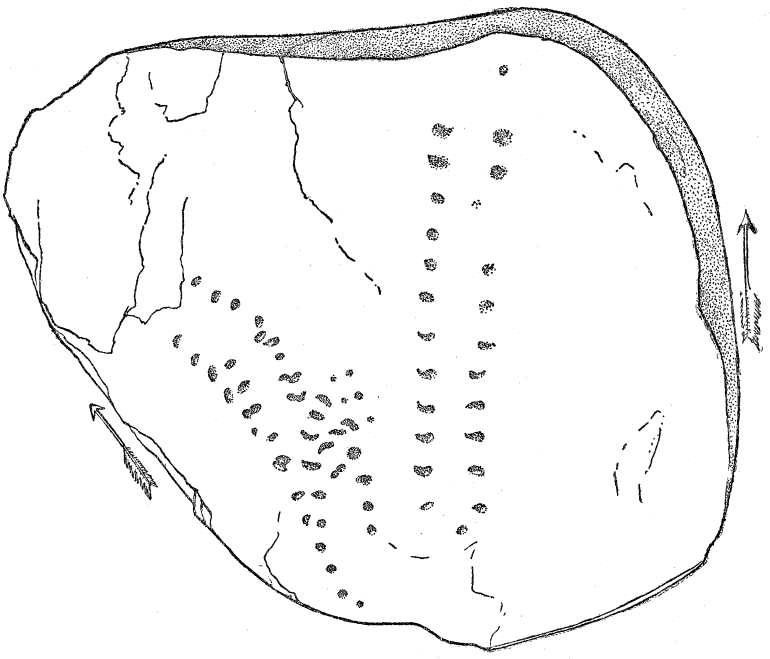

FIGURE 5.

its elliptical body. The trail seems to indicate the occurrence of a merostome of a group not represented by any known fossil genus, unless it should prove to be a young Protolimulus.

*Merostomichnites narragansettensis* (Pack.). Fig. 5. Proc. Amer. Acad. Arts and Sci. XXXV. No. 20, April, 1900, p. 402. Three trails of this species were discovered by a member of my geological class, — Mr. H. H. Mason, of the class of 1900, — and kindly given to me, while doing field work under my direction in Providence, R. I., just north of the city and of the North Burying Ground. The trails occurred in a rounded pebble of dark arenaceous shale picked up from the mass of water-worn gravel and boulders constituting the body of a large rounded kame. It was split in two, so as to show the impressions and the relief of the tracks. The subglacial deposits at this point are derived from a region a few miles a little east of north, probably in the vicinity of South Attleboro, though I have not seen beds of this peculiar blackish sandy shale in place.

There are three trails, — one separate, and the two others crossing each other. The long separate series is nearly straight, 6.50 cm. in length ; the other trail is sinuous, and is crossed by a third, shorter trail. The width of each trail is the same, being about 12 mm. outside measurement. The distance between the individual tracks of the same pair is about 9 mm., that between the footprints on the same side varies from about 2 mm. to about 4 mm.

The tracks are opposite and not alternate. Along most of the length of the trail there is but a single series of tracks on a side, but in portions of the entire trail the footprints are double, there being an inner and an outer set on each side. If we select four of the tracks in a place where they are double, it will be seen that they are arranged in a very low trapezoid; while the space between the two outside tracks is 9 mm., that between the two inner, a little in advance, is 5 mm.

The individual tracks forming the trails are of quite uniform shape, the best marked ones being transversely oval or crescentic in outline, the mud having been pushed back by the animal's feet so as to leave a crescentic ridge, the concavity pointing forward. The size of the impression in transverse diameter is about 3 mm., the longitudinal diameter 1.5, i. e. the tracks are about twice as broad as long. Thus they are not linear, and more or less parallel to the main series of tracks, as in those referred to the decapod crustacea. In two or three cases the tracks are connected by a slight ridge curved forward in the direction the animal moved.

While these tracks are certainly not Isopod tracks, they with still more certainty cannot be referred to impressions made by the feet of insects, which are always alternate, as in hexapod insects the legs of each pair are raised and put down alternately. The Providence carboniferous tracks were evidently made by an arthropod of the same group as Limulus, as the tracks are opposite, and in general shape like those of Limulus, as may be seen by Fig. 1. The present tracks differ from those of Limulus in the absence of a caudal spine trail-mark, and in the fact that an additional anterior pair of feet made impressions. Trilobites are not known to exist in our Upper Carboniferous associated with Limulus. Limuloids of the genus Prestwichia with a short caudal spine exist in considerable numbers in the Upper Carboniferous of Mason Creek, Illinois, and in the Upper Carboniferous beds of Pennsylvania, though from a horizon higher than that of the Mason Creek beds. As the genus Belinurus has a very long caudal spine, and there are no traces of a median furrow in our trails, that genus should be ruled out as the author of these tracks. Now the adult Prestwichia is about two inches in diameter and its caudal spine nearly half an inch in length. It is, however, well known that in the freshly hatched Limulus, and even after the first moult, and when the creatures are half an inch in diameter, the caudal spine is very short, too much so, probably, to leave a trail or median furrow.

The Providence trails are considerably less than half an inch in diameter, and reasoning by analogy, and also in part by exclusion, it seems not impossible that these trails are the footprints of a young Prestwichia a little less than half an inch in diameter, with too short a caudal spine to leave a furrow.

This conclusion is interesting as suggesting the occurrence of these Limuloids in the Narragansett basin during the later part of the Carboniferous Period. These tracks are so similar to those of the Chemung beds above described that they were probably made by Merostomes of the same family or genus, and may be referred to Merostomichnites rather than to Protichnites.

The possibility that these trails could have been made by an Eurypterid seems excluded by the absence of a median furrow, or of any prints made by the large paddles of the hind feet, or by the paddles and chelae of the first pair of feet of such a form as Pterygotus.

Brown University.